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Author: Andreas Palm, Christer Janson, Eva Lindberg

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The impact of obesity and weight gain on development of sleep problems in a population-based sample

Andreas Palm MD^{a,b*}, Christer Janson MD, PhD^a, Eva Lindberg MD, PhD^a

^aDepartment of Medical Sciences, Respiratory Medicine and Allergology, Uppsala University, Sweden.

^bCentre for Research and Development, Uppsala University, County Council of Gävleborg, Sweden

*Corresponding author. Department of Pulmonary Medicine, Gävle Hospital, 806 27 Gävle, Sweden;

Tel: +46 26 1540 00; Email: andreas.palm@lg.se

Key words: Weight gain; overweight; obesity; sleep problems; insomnia, sleepiness

The authors have no conflicts of interest to declare.

Abbreviations: BMI=body mass index; CI=confidence interval; DIS=difficulties initiating sleep;

DMS=difficulties maintaining sleep; EDS=excessive daytime sleepiness; GERD=gastro esophageal

reflux disease; OR=odds ratio

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Highlights

- The role of obesity and weight gain on the development of sleep problems in a population-based cohort was studied.
- Overweight and obese subjects reported more sleep problems at baseline.
- There was no independent association between BMI-level at baseline and development of new sleep problems.
- Weight gain was an independent risk factor for developing several sleep problems and daytime sleepiness.

Abstract

Objectives: To investigate the role of obesity and weight gain on the development of sleep problems in a population-based cohort.

Material and methods: A population-based sample of men (n=1,896, aged 40-79 years) and women (n=5,116, age ≥ 20 years) responded to questionnaires at baseline and follow-up after 10-13 years.

Sleep problems were assessed through questions about difficulties initiating sleep (DIS), difficulties maintaining sleep (DMS), excessive daytime sleepiness (EDS) and insomnia. Body mass index (BMI) was calculated from self-reported weight and height at both baseline and follow-up while confounding factors (physical activity, tobacco and alcohol use, somatic disease and snoring) were based on responses at baseline.

Results: Although overweight and obese subjects reported more sleep problems at baseline, there was no independent association between BMI-level at baseline and development of new sleep problems. Subjects in the quartile with the highest rise in BMI with a weight gain exceeding 2.06 kg/m² had a higher risk of developing DMS (Adjusted OR 1.58; 95% CI 1.25-2.01), EDS (2.25; 1.65-3.06) and insomnia (2.78; 1.60-4.82). Weight gain was not associated the development of DIS.

Conclusions: Weight gain is an independent risk factor for developing several sleep problems and daytime sleepiness. The presence of overweight and weight gain should be considered when treating patients with sleep problems.

Introduction

In the general population, approximately 6-10% experience insomnia and 30-39% experience sleep problems, and the prevalence rates are increasing(1-3). Parallel with this, the worldwide prevalence of obesity is increasing rapidly (4). Cross-sectional studies reveal sleep problems and daytime sleepiness are associated with obesity (5-10) and the association is independent of the coexistence of obstructive sleep apnea (OSA)(6, 11).

Short and long sleep time(12, 13) as well as insomnia and sleep problems are risk factors for weight gain(14, 15). Although weight gain is a well-known risk factor for the development of snoring(16) and sleep apnea(17), the impact of weight gain on other sleep problems is still unknown.

The aim of this study was to investigate the role of obesity and weight gain on the development of sleep problems in a population-based cohort.

Material and methods

Population

Two cohorts in the municipality of Uppsala, Sweden, were assessed. Sleep and Health is an on-going cohort study focusing on the impact of sleeping habits and sleep disorders on health. The male cohort was first investigated in 1984 when 4021 men aged 30-69 years were randomly selected from the population registry for the Municipality of Uppsala, Sweden. All responders still alive 1994 (n=3201) were sent a postal questionnaire, with a response rate of 89.7% (n=2668): this constituted the baseline investigation in the present study. All responders still alive in 2007 (n= 2231) were sent a follow-up questionnaire with a response rate of 91.4% (n=2040).

The female cohort was first investigated in 2000 when a baseline postal questionnaire was sent to a random sample of women aged ≥ 20 years and living in the same area. Of the 7051 women who responded and who were still alive (n=6590) were sent a follow-up questionnaire in 2010 with a response rate of 80.5 % (n=5193)(18). All men and women who had participated both at baseline and follow-up and who provided information about their height and weight on both occasions were included in the present study (n=7012).

Questionnaire

All questions used in the analyses were identical at baseline and follow-up for both men and women.

Body mass index

Body mass index (BMI) was calculated from self-reported body weight in kilograms divided by self-reported height in meters squared (kg/m^2).

Based on BMI the subjects were categorized into underweight ($\text{BMI} < 20$), normal weight ($\text{BMI} 20\text{--}24.99$), overweight ($\text{BMI} 25\text{--}29.99$) and obese ($\text{BMI} \geq 30$). Delta-BMI ($\Delta\text{-BMI}$) was defined as BMI at follow up minus BMI at baseline. Due to an U-shaped association between weight gain and incident sleep problems, it was not possible to use $\Delta\text{-BMI}$ as a continuous variable. $\Delta\text{-BMI}$ was therefore divided into quartiles where quartile 1 was subjects with $\Delta\text{-BMI} < -0.32$, quartile 2 was $\Delta\text{-BMI} 0.32\text{--}0.76$, quartile 3 was $\Delta\text{-BMI} 0.76\text{--}2.06$ and quartile 4 was $\Delta\text{-BMI} \geq 2.06$.

Leisure time physical activity

The subjects reported their level of physical activity during leisure time on a 4-point scale(19). In the statistical analysis the level of physical activity was categorized in three groups. A low level of physical activity was defined as score 1; spending most time watching television, reading and being sedentary for most of their leisure time. A medium level was defined as score 2; some physical activity, such as walking and cycling, at least four hours a week. A high physical activity level was defined as scores 3-4. This included regular participation for three hours a week or more vigorous exercise on a weekly basis in for example swimming, jogging, tennis and aerobic exercise.

Smoking

Smoking habits were assessed by six questions (20) and the number of pack-years was calculated based on the responses. The participants were classified into three categories, never smokers (0 pack-years), those with a smoking history of >0 to 19.99 pack-years and those with a smoking history of ≥ 20 pack-years.

Alcohol dependence

Alcohol dependence was analyzed with the CAGE questionnaire (Cut down, annoyed by criticism, guilt about drinking, eye-opener drinks) (21). Participants answering yes to at least two of the questions were categorized as alcohol dependent.

Somatic diseases

Somatic diseases were based on self-reported data. Subjects were asked if they had hypertension, heart disorders, diabetes and asthma, the response options were “yes” or “no”.

Subjects were also asked on a five-graded scale, how often they had gastro esophageal reflux. If the answer was “sometimes”, “often” or very often” they were considered to be suffering from gastro esophageal reflux disease (GERD), in contrast to those who answered “rarely” and “never”.

Snoring

Frequency of snoring loudly and disturbingly was assessed with a five-graded scale. Those who answered “often” or “very often” were considered as snorers, whereas subjects answering “never”, “rarely” and “sometimes” were considered as non-snorers.

Sleep problems

The participants were asked to grade, on a five-grade scale, how much problems they had with falling asleep at night, with waking up during the night and with sleepiness at daytime. The response options were “none”, “small”, “moderate”, “severe” and “very severe”. If the subjects answered

“severe” or “very severe”, they were considered positive for difficulties in initiating sleep (DIS), difficulties in maintaining sleep (DMS), and excessive daytime sleepiness (EDS).

The variable “insomnia” was defined here as either, or both, DIS and DMS in combination with EDS.

In the subsequent analyzes, subjects who developed DIS, DMS, EDS and insomnia were identified among those who did not report the respective sleep problem at baseline.

Statistical analyses

Statistical analyses were performed using Stata 12.1 (StataCorp, Texas, USA).

Differences between groups were compared with χ^2 -test for categorical variables and analysis of variance, ANOVA, for continuous variables. Multiple logistic regression analysis was used to examine the statistical independence of the suggested risk factors for developing sleep disorders. The results are presented as odds ratios (OR) and 95% confidence interval (95% CI). Interaction analysis was added to the multiple logistic regression analysis to examine whether interaction existed between the degree of weight gain and gender, age and BMI-category at baseline. A p-value of <0.05 was considered statistically significant.

Ethics

Informed consent was obtained from all participants. The Ethics Committee of the Medical Faculty at Uppsala University, Uppsala, Sweden approved the study.

Results

The prevalence of DMS at baseline increased with increasing weight whereas the prevalence of DIS, EDS and insomnia was highest both among those who were underweight and those with obesity (Table 1). The prevalence of all measured sleep problems and daytime sleepiness at baseline, was higher among women than among men (Figure 1). The average rise in BMI during the follow-up period was $0.93 \pm 2.75 \text{ kg/m}^2$. Men had a higher BMI ($25.4 \pm 3.6 \text{ kg/m}^2$ versus $24.0 \pm 4.1 \text{ kg/m}^2$, $p < 0.001$) at baseline but a lower rise in BMI ($0.64 \pm 2.89 \text{ kg/m}^2$ versus $1.03 \pm 2.69 \text{ kg/m}^2$) during the follow-up period. The highest rate of weight gain was observed in younger age groups. The demographic characteristics at baseline by change in BMI during the follow-up period are presented in Supplementary Table 1. The subjects with the highest increase in BMI had a lower level of physical activity and were more dependent on smoking and alcohol. The participants with weight loss during the follow-up period had the highest BMI at baseline and had the highest prevalence of hypertension, heart disease and snoring.

Weight gain

There were U-shaped associations between weight gain and development of DIS, DMS, EDS and insomnia (Figure 2). The incidence of sleep problems and EDS were high within the group of participants who lost weight, but not as prominent as within the group who gained most weight.

Multivariate analysis

To further examine the influence of changes in weight on future sleep problems, multiple logistic regression analysis was performed adjusting for gender, BMI at baseline, age, physical activity, smoking, alcohol use, somatic disease and snoring (Table 2). There was an increased risk of developing DMS, EDS and insomnia among the subjects in the quartile with the highest rise in BMI. In contrast, there was no association between BMI at baseline and the risk of developing sleep

problems. Ageing increased the risk of developing DIS, but reduced the risk of developing DMS, EDS and insomnia. Female gender was an independent risk factor for developing DMS.

Gastro esophageal reflux disease (GERD) at baseline was a risk factor for development of all sleep problems, even after adjusting for confounders. Heart problems and asthma at baseline were associated with an increased risk of developing DIS, EDS and insomnia but not with developing DMS. Smoking was associated with a higher risk of developing DIS and DMS, whereas a low level of physical activity and alcohol dependence were independent predictors of incident EDS.

There was an interaction between high Δ -BMI and the group with normal BMI at baseline in relation to development of insomnia (Adjusted OR 3.88; 1.74-8.63) ($p_{\text{interaction}} = 0.047$). There was no significant gender or age interaction between weight gain and the risk of developing sleep problems.

Discussion

The main finding of this longitudinal study was that weight gain itself was an independent risk factor for development of DMS, EDS and insomnia, but not for developing DIS.

At baseline, the prevalence of sleep problems increased parallel with BMI and underweight subjects also had a higher prevalence of DIS and EDS. The U-shaped association between body weight and sleep problems was consistent with findings from previous cross-sectional studies(5-10). The overall higher prevalence of sleep problems in women was in accordance with previous studies(3, 10, 22).

No longitudinal association was found between BMI-level at baseline and development of sleep problems. This may be due to sleep problems already being more common among obese subjects. A previous prospective study (23) reported an association between obesity at baseline and development of insomnia during a 7.5 year follow-up period but after controlling for sociodemographic and behavioral factors this association was no longer significant. In the same cohort, obesity at baseline was a risk factor for developing poor sleep, defined as incident DIS, DMS, EDS and early morning awakenings(24). This association was significant even after adjusting for confounders. However, the effect of weight gain over time was not analyzed in either study.

The relation between development of a new sleep problem and weight gain was U-shaped with the highest incidence among those who gained most weight and among those who lost weight. The association between underweight, weight loss and sleep problems is most likely linked with medical illness and health problems as sleep disorders and weight loss are often comorbid with medical and psychiatric conditions(2, 9, 10, 22, 25). The observed associations between heart disease, asthma, GERD and development of sleep problems further confirmed this.

Ageing was found to be a risk factor for developing DIS but protected from development of DMS, EDS and insomnia. However, results from other studies are inconsistent. In a cross-sectional study Gislason and Almqvist (25) showed an increase of DMS with ageing but after adjustment for somatic disease and obesity, this association disappeared. A previous cross-sectional studies have shown a decline of EDS with increasing age(5) but with a higher prevalence of EDS among those with age over 75 years . This increase may be associated with age related health problems(8). In a longitudinal study by Singareddy et al, a marginal decline in new onset of insomnia was observed with higher age(23). Although other studies have reported increasing sleep problems with increasing age(10, 22),

the data from these studies are not comparable with the present study, as all sleep problems were merged in these studies and DIS, DMS, EDS and insomnia were analyzed separately in this study.

In the present study we found that weight gain was associated with the development of insomnia. It is also known from previous studies that short and long sleep, insomnia and sleep problems are associated with obesity and weight gain (12-15, 26). We therefore suggest that weight gain and sleep problems create a vicious circle.

Strength and weaknesses

The strengths of this study were the longitudinal design, the size of the cohort, the long follow-up time and the high participation rates. BMI and the occurrence of sleep disorders were examined at both baseline and follow up. However, some limitations should be taken into account when interpreting the results. The study population was pooled from two different cohorts, one with men aged 40-79 years with a follow-up after 13 years and one with women aged over 20 years with a follow-up after 10 years. However, no significant gender or age interaction between weight gain and the risk of developing sleep problems was found in the interaction analysis. All data were self-reported and over reporting of length and underreporting of weight are common(27), thus, associations between obesity and health conditions may be overestimated if self-reported BMI is used(28). However, it could be assumed that an underestimation of weight would influence BMI both at baseline and follow-up in the same direction and Δ -BMI, that is the main variable, would be less sensitive. Another weakness is the definition of insomnia that was based on responses on DIS, DMS and EDS in questionnaires. Although the insomnia variable was similar to the ICD10 definition of nonorganic insomnia, there was not enough information to rule out any known causative organic factor. As definitions of insomnia and sleep problems vary, the findings and prevalence rates are difficult to compare with other studies.

In addition, the questionnaires did not include questions about psychiatric or psychosocial problems, which are associated with sleep problems (2, 23, 24) and depression and pharmacotherapy against psychiatric diseases are associated with change of weight(29, 30). Therefore future studies should consider psychiatric and psychosocial aspects.

Conclusions

Weight gain is an independent risk factor for developing several sleep problems and daytime sleepiness. The presence of overweight and weight gain should be considered when treating patients with sleep disorders.

Acknowledgements

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Figure legends

Figure 1. Prevalence of sleep problems at baseline by gender.

DIS= Difficulties initiating sleep, DMS=Difficulties maintaining sleep, EDS= Excessive daytime sleepiness. *** = $p < 0.001$.

Figure 2. Incidence of new sleep problems by change in BMI. The participants are divided into quartiles., quartile 1 with $\Delta\text{-BMI} < -0.32$; quartile 2 with $\Delta\text{-BMI} \geq -0.32 - < 0.76$; quartile 3 with $\Delta\text{-BMI} \geq 0.76 - < 2.06$; and, quartile 4 with $\Delta\text{-BMI} \geq 2.06$.

DIS= Difficulties initiating sleep, DMS=Difficulties maintaining sleep, EDS= Excessive daytime sleepiness.

Table 1. Prevalence of sleep problems by BMI at baseline by gender. (DIS= Difficulties inducing sleep, DMS=Difficulties maintaining sleep, EDS= Excessive daytime sleepiness, Insomnia=DIS and/or DMS in combination with EDS).

		n (%)	DIS	DMS	EDS	Insomnia
Men	All	1896	5.1	9.4	5.7	1.8
	BMI <20	34 (1.8)	8.8	8.8	6.1	3.0
	20≤BMI<25	878 (46.3)	5.0	7.3	4.8	1.6
	25≤BMI<30	865 (45.6)	4.6	11.1	6.3	1.9
	BMI≥30	119 (6.3)	7.6	13.6	8.5	1.7
Women	All	5116	8.2	15.0	13.9	4.3
	BMI <20	550 (10.8)	8.8	12.2	16.6	4.7
	20≤BMI<25	2949 (57.6)	7.3	13.9	12.9	3.8

25≤BMI<30	1195 (23.4)	9.0	17.5	14.7	5.0
BMI≥30	422 (8.3)	10.9	18.8	14.8	5.3

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Table 2. Risk factors for developing sleep problems during the follow-up period. Data are presented as adjusted odds ratio (95% CI) after adjusting for all variables in the table. DIS= Difficulties inducing sleep, DMS=Difficulties maintaining sleep, EDS= Excessive daytime sleepiness. Insomnia=DIS and/or DMS in combination with EDS.

New sleep disorder	New DIS	New DMS	New EDS	New Insomnia
n/Evaluable subjects	328/5615	756/5245	457/5313	158/5776
Gender, Women	1.38 (1.02-1.88)	1.27 (1.03-1.57)	1.14 (0.87-1.499)	0.88 (0.55-1.39)
Δ-BMI mean range				
<-0.32	1.26 (0.88-1.79)	1.09 (0.85-1.41)	1.44 (1.03-2.02)	1.73 (0.95-3.13)
"-0.32-<0.76	1	1	1	1
0.76-<2.06	1.12 (0.78-1.62)	1.21 (0.95-1.54)	1.34 (0.96-1.86)	1.22 (0.65-2.27)
≥2.06	1.36 (0.95-1.95)	1.58 (1.25-2.01)	2.25 (1.65-3.06)	2.78 (1.60-4.82)
BMI category at baseline				
<20	1.16 (0.73-1.85)	0.94 (0.89-1.28)	0.80 (0.53-1.20)	0.97 (0.50-1.88)
20-<25	1	1	1	1
25-<30	0.91 (0.68-1.23)	1.03 (0.84-1.26)	1.03 (0.80-1.33)	1.05 (0.68-1.61)
≥30	1.37 (0.89-2.11)	0.93 (0.66-1.31)	0.97 (0.84-1.47)	0.87 (0.42-1.82)
Age increase by 10 ys	1.16 (1.05-1.28)	0.91 (0.84-0.97)	0.79 (0.72-0.86)	0.83 (0.71-0.97)
Level of physical activity				
High	1	1	1	1
Medium	1.30 (0.92-1.85)	1.01 (0.82-1.25)	1.10 (0.83-1.44)	1.06 (0.66-1.69)

Low	1.26 (0.81-1.96)	1.24 (0.95-1.64)	1.74 (1.25-2.42)	1.25 (0.69-2.25)
Smoking habits				
Never smoker	1	1	1	1
>0-19.99 pack-years	1.09 (0.82-1.44)	1.26 (1.05-1.53)	1.16 (0.91-1.47)	1.08 (0.72-1.61)
≥20 pack-years	1.53 (1.06-2.21)	1.78 (1.36-2.32)	1.24 (0.87-1.77)	0.92 (0.48-1.76)
Alcohol dependence	1.19 (0.75-1.89)	1.23 (0.91-1.65)	1.75(1.25-2.43)	1.11 (0.60-2.08)
Hypertension	1.34 (0.90-2.00)	1.07 (0.77-1.48)	1.08 (0.72-1.62)	1.38 (0.74-2.57)
Heart problems	1.87 (0.97-2.89)	1.31 (0.82-2.10)	2.22 (1.31-3.76)	1.38 (1.09-5.20)
Diabetes	1.13 (0.50-2.55)	1.01 (0.50-2.01)	1.22 (0.56-2.65)	2.03 (0.69-5.95)
Asthma	1.64 (1.04-2.57)	1.33 (0.94-1.88)	1.92 (1.31-2.80)	1.86 (1.02-3.37)
Gastroesophageal reflux	1.63 (1.18-2.26)	1.59 (1.25-2.02)	1.60 (1.20-2.15)	1.92 (1.22-3.03)
Snoring	0.69 (0.45-1.06)	1.39 (1.08-1.79)	1.30 (0.94-1.79)	0.80 (0.43-1.51)

Supplementary table 1. Characteristics of participants at baseline by change in BMI during the follow-up period. The participants are divided into quartiles, quartile 1 with Δ -BMI <-0.32; quartile 2 with Δ -BMI \geq -0.32 - <0.76; quartile 3 with Δ -BMI \geq 0.76-<2.06; and, quartile 4 with Δ -BMI \geq 2.06.